Lisachem Materials

Chemistry Physics Biology Psychology

VCE CHEMISTRY 2007
TRIAL EXAM YEAR 12
UNIT 4

Time allowed: 90 minutes
Total marks: 80

SECTION A
Contains 20 multiple choice questions
22 minutes, 20 marks

SECTION B
5 Extended response questions
68 minutes, 60 marks

A data sheet and multiple choice answer sheet are provided. Answer extended response questions in the space provided. Use the marks and time allowed as a guide to how much time you should spend answering each question.

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relative atomic number
symbol
name
relative atomic mass

							1 H Hydrogen 1.0										2 He Helium 4.0
3 Li Lithium 6.9	4 Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 N Nitrogen 14.0	8 O Oxygen 16.0	9 F Fluorine 19.0	10 Ne Neon 20.2
11 Na Sodium 23.0	12 Mg Magnesium 24.3											13 Al Aluminium 27.0	14 Si Silicon 28.1	15 P Phosphorus 31.0	16 S Sulfur 32.1	17 Cl Chlorine 35.5	18 Ar Argon 39.9
19 K Potassium 39.1	20 Ca Calcium 40.1	21 Sc Scandium 44.9	22 Ti Titanium 47.9	23 V Vanadium 50.9	24 Cr Chromium 52.0	25 Mn Manganese 54.9	26 Fe Iron 55.9	27 Co Cobalt 58.9	28 Ni Nickel 58.7	29 Cu Copper 63.6	30 Zn Zinc 65.4	31 Ga Gallium 69.7	32 Ge Germanium 72.6	33 As Arsenic 74.9	34 Se Selenium 79.0	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.5	38 Sr Strontium 87.6	39 Y Yittrium 88.9	40 Zr Zirconium 91.2	41 Nb Niobium 92.9	42 Mo Molybdenum 95.9	43 Tc Technetium 98.1	44 Ru Ruthenium 101.1	45 Rh Rhodium 102.9	46 Pd Palladium 106.4	47 Ag Silver 107.9	48 Cd Cadmium 112.4	49 In Indium 114.8	50 Sn Tin 118.7	51 Sb Antimony 121.8	52 Te Tellurium 127.6	53 I Iodine 126.9	54 Xe Xenon 131.3
55 Cs Caesium 132.9	56 Ba Barium 137.3	57 La Lanthanum 138.9	72 Hf Hafnium 178.5	73 Ta Tantalum 180.9	74 W Tungsten 183.8	75 Re Rhenium 186.2	76 Os Osmium 190.2	77 Ir Iridium 192.2	78 Pt Platinum 195.1	79 Au Gold 197.0	80 Hg Mercury 200.6	81 Tl Thallium 204.4	82 Pb Lead 207.2	83 Bi Bismuth 209.0	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (266)	107 Ns Neilsbohrium (264)	108 Hs Hassium (269)	109 Mt Meitnerium (268)	110 Ds Darmstadtium (272)	111 Rg Roentgenium (272)	112 Uub Ununbium (277)		114 Uuq Ununquadium (289)				

Lanthanide series	58 Ce Cerium 140.1	59 Pr Praseodymium 140.9	60 Nd Neodymium 144.2	61 Pm Promethium (145)	62 Sm Samarium 150.3	63 Eu Europium 152.0	64 Gd Gadolinium 157.2	65 Tb Terbium 158.9	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9	68 Er Erbium 167.3	69 Tm Thulium 168.9	70 Yb Ytterbium 173.0	71 Lu Lutetium 175.0
Actinide series	90 Th Thorium 232.0	91 Pa Protactinium 231.0	92 U Uranium 238.0	93 Np Neptunium 237.1	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (255)	103 Lr Lawrencium (256)

Data Sheet VCE Chemistry 2007 Trial Exam Year 12 Unit 4

Physical Constants

F = 96 500 C mol^{-1}

R = 8.31 JK^{-1} mol^{-1}

V_m (STP) = 22.4 L mol^{-1}

V_m (SLC) = 24.5 L mol^{-1}

Specific heat of water = 4.18 J g^{-1} $^oC^{-1}$

Ideal gas equation

$pV = nRT$

The Electrochemical Series

		$E°$ in volt
$F_2(g) + 2e^-$	$\rightarrow 2F^-(aq)$	+ 2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^-$	$\rightarrow 2H_2O(l)$	+ 1.77
$Au^+(aq) + e^-$	$\rightarrow Au(s)$	+ 1.68
$MnO_4^-(aq) + 8H^+(aq) + 5e^-$	$\rightarrow Mn^{2+}(aq) + 4H_2O(l)$	+ 1.50
$Cl_2(g) + 2e^-$	$\rightarrow 2Cl^-(aq)$	+ 1.36
$O_2(g) + 4H^+(aq) + 4e^-$	$\rightarrow 2H_2O(l)$	+ 1.23
$Br_2(l) + 2e^-$	$\rightarrow 2Br^-(aq)$	+ 1.09
$Ag^+(aq) + e^-$	$\rightarrow Ag(s)$	+ 0.80
$Fe^{3+}(aq) + e^-$	$\rightarrow Fe^{2+}(aq)$	+ 0.77
$I_2(s) + 2e^-$	$\rightarrow 2I^-(aq)$	+ 0.54
$O_2(g) + 2H_2O(l) + 4e^-$	$\rightarrow 4OH^-(aq)$	+ 0.40
$Cu^{2+}(aq) + 2e^-$	$\rightarrow Cu(s)$	+ 0.34
$CO_2(g) + 8H^+(aq) + 8e^-$	$\rightarrow CH_4(g) + 2H_2O(l)$	+ 0.17
$S(s) + 2H^+(aq) + 2e^-$	$\rightarrow H_2S(g)$	+ 0.14
$2H^+(aq) + 2e^-$	$\rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^-$	$\rightarrow Pb(s)$	- 0.13
$Sn^{2+}(aq) + 2e^-$	$\rightarrow Sn(s)$	- 0.14
$Ni^{2+}(aq) + 2e^-$	$\rightarrow Ni(s)$	- 0.23
$Co^{2+}(aq) + 2e^-$	$\rightarrow Co(s)$	- 0.28
$Fe^{2+}(aq) + 2e^-$	$\rightarrow Fe(s)$	- 0.44
$Zn^{2+}(aq) + 2e^-$	$\rightarrow Zn(s)$	- 0.76
$2H_2O(l) + 2e^-$	$\rightarrow H_2(g) + 2OH^-(aq)$	- 0.83
$Mn^{2+}(aq) + 2e^-$	$\rightarrow Mn(s)$	- 1.03
$Al^{3+}(aq) + 3e^-$	$\rightarrow Al(s)$	- 1.67
$Mg^{2+}(aq) + 2e^-$	$\rightarrow Mg(s)$	- 2.34
$Na^+(aq) + e^-$	$\rightarrow Na(s)$	- 2.71
$Ca^{2+}(aq) + 2e^-$	$\rightarrow Ca(s)$	- 2.87
$K^+(aq) + e^-$	$\rightarrow K(s)$	- 2.93
$Li^+(aq) + e$	$\rightarrow Li(s)$	- 3.02

VCE Chemistry 2007 Year 12 Trial Exam Unit 4

Section A

Section A consists of 20 multiple-choice questions.
Section A is worth approximately 25 per cent of the marks available.
You should spend approximately ***22 minutes*** *on this section.*
Choose the response that is ***correct*** *or* ***best answers*** *the question.*
Indicate your choice on the answer sheet provided.

Question 1.

Copper (II) hydroxide is relatively insoluble in water but will can dissolve in 2 M ammonia solution according to the equilibrium

$$Cu(OH)_2(s) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4^{2+}(aq) + 2OH^-(aq)$$

The chemical formula of an hydroxide which would be most likely to react in a similar way in 2 M ammonia solution is

A. NaOH
B. $Ni(OH)_2$
C. $Mg(OH)_2$
D. LiOH

Question 2.

The operation of a nuclear device depends on the availability of a particular isotope, Y. At sufficiently high temperatures the following self-sustaining set of reactions can be initiated

$$Y + {}^{1}n \rightarrow {}^{4}He + X \qquad \textbf{1.}$$

$$X + X \rightarrow {}^{4}He + 2\,{}^{1}n \qquad \textbf{2.}$$

Y is an isotope of

A. hydrogen
B. beryllium
C. lithium
D. carbon

Question 3.

The fact that there must be a limit on the number of electrons which may be present in an atomic orbital was first recognised by

A. Pauli
B. Bohr
C. Rutherford
D. Dalton

Question 4.

When light from a sodium lamp is viewed through a spectroscope a series of coloured lines appears on a black background. This effect is due to the fact that

A. when sodium atoms are excited they absorb particular wavelengths of light as electrons drop back from a higher energy level to a lower energy level.
B. when sodium atoms are excited they emit energy as electrons move from energy levels close to the nucleus to energy levels further from the nucleus
C. when sodium atoms are excited electrons are promoted to higher energy levels each of these energy levels is represented by one of the coloured lines.
D. when sodium atoms are excited they absorb energy, which is then emitted as particular wavelengths of light as electrons return to lower energy levels.

Question 5.
An element which has high electronegativity could also be expected to
A. exist as a cation in many of its compounds
B. form a basic oxide
C. have a high first ionisation energy
D. be a strong reductant.

Question 6.
Which of the following statements about Mendeleev's periodic table is not correct?
A. There were gaps in his table
B. Each element had an atomic weight greater than the one before it
C. The table was used to predict the existence of some then unknown elements
D. The elements were arranged into vertical groups of elements with similar chemical properties.

Question 7.
Elements other than hydrogen are believed to have been manufactured by nuclear reactions occurring inside stars. As these reactions proceed within a star, the number of nuclei in the star
A. increases, and the mass of the star decreases
B. decreases, and the mass of the star increases
C. increases, and the mass of the star increases
D. decreases, and the mass of the star decreases

Question 8.
Electrolysis of 1 L of a 1.0 M $Cu(NO_3)_2(aq)$ solution using platinum electrodes results in copper being plated onto the negative electrode. The concentration of $Cu^{2+}(aq)$ in the solution after the passage of 20000 C of electrical charge is closest to
A. 0.1 M
B. 0.2 M
C. 0.8 M
D. 0.9 M

Question 9.
1 L of an aqueous solution contains 0.02 mol of each of the dissolved salts $FeCl_2$, $ZnCl_2$ and $CuCl_2$. Two graphite rods are placed in the solution and electrolysis is started. At the end of the electrolysis, all of the metal ions have been reduced at one of the graphite rods.

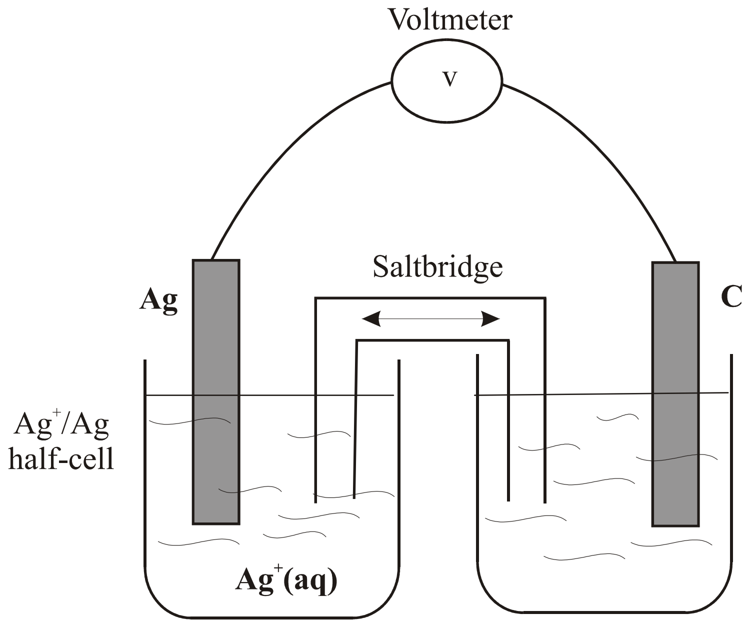
The three coatings on this graphite rod would be expected to be in the following order, from the inside to the outside
A. Zn Fe Cu
B. Fe Cu Zn
C. Cu Zn Fe
D. Cu Fe Zn

Question 10.
When a lead acid-accumulator, used as a common car battery, is being recharged, i.e. converting electrical energy into chemical energy, the following redox reaction occurs

$$2PbSO_4(s) + 2H_2O(l) \rightarrow Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq)$$

When a lead acid accumulator is discharging, i.e. delivering electrical energy
A. PbO_2 is reduced at the positive electrode
B. the pH decreases
C. the oxidation numbers of lead changes from +4 to +2 at the negative electrode.
D. H^+ is oxidised to water

Question 11.
The following galvanic cell was set up in a secondary college laboratory. All solutions were 1 M and at 25°C



Saltbridge

According to the electrochemical series, under standard conditions the cell should have a potential difference of 0.26 V. The reaction occurring at the right hand electrode would be

A. $Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$
B. $I_2(s) + 2e^- \rightarrow 2I^-(aq)$
C. $2I^-(aq) \rightarrow I_2(s) + 2e^-$
D. $2Br^-(aq) \rightarrow Br_2(l) + 2e^-$

Question 12.
The Australian Government's commonwealth cars now run on E10 ethanol blended fuel where ever possible. E10 fuel is a mixture of 10 per cent ethanol and 90 per cent petrol (octane).
The thermochemical equations for the combustion of octane and ethanol are shown below.

$$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g),\ \Delta H = -10090 \text{ kJ mol}^{-1}$$
$$C_2H_5OH(l) + 9O_2(g) \rightarrow 2CO_2(g) + 6H_2O(g),\ \Delta H = -1367 \text{ kJ mol}^{-1}$$

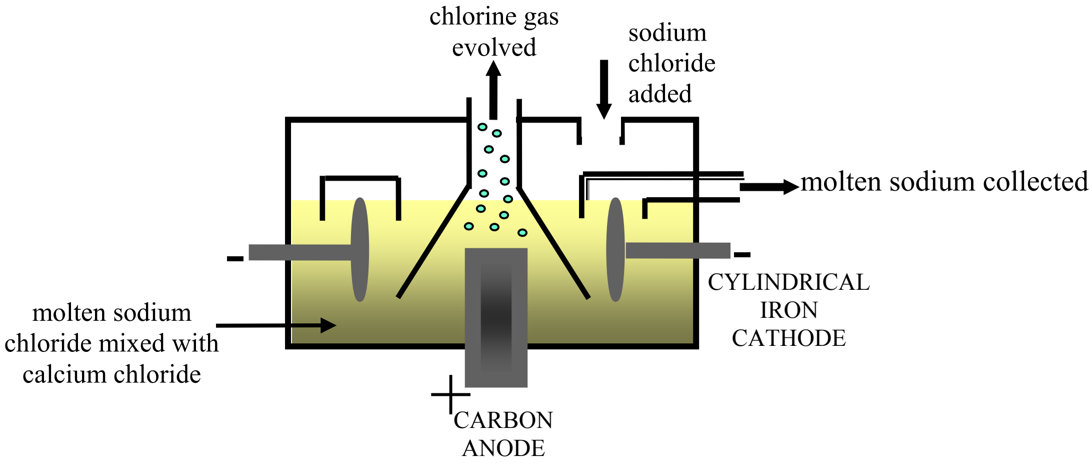
Compared to the combustion of octane, the combustion of ethanol

A. releases more energy for each gram combusted.
B. produces more CO_2 for each kJ of energy released.
C. uses less O_2 for each kJ of energy produced.
D. produces less CO_2 for each gram combusted.

Question 13.
An aqueous solution calorimeter containing 150 g of water was calibrated electrically. If the calorimeter was well insulated, the calibration factor (calorimeter constant) would be expected to be closest to?

A. 450 J K^{-1}
B. 700 J K^{-1}
C. 1.50 kJ K^{-1}
D. 630 kJ K^{-1}

Questions 14 and 15 refer to the electrolytic cell diagram shown below



Question 14.

The electrolytic cell shown in the diagram is commonly known as the

A. Down's cell
B. Hall Cell
C. Diaphragm cell
D. Membrane cell

Question 15.

A possible explanation for the use of an iron cathode but a carbon anode is

A. sodium is a stronger reductant than iron and so is preferentially reduced.
B. iron is a stronger reductant than chloride ions and would be preferentially oxidised.
C. calcium ions would be reduced in preference to sodium ions at a carbon cathode
D. an iron anode would dissolve in the molten electrolyte.

Question 16.

During an electrolysis experiment, oxygen gas was produced at the (+) electrode. The electrolyte in the experiment could **not** have been

A. 1 M $NaOH(aq)$
B. 1 M $MgCl_2(aq)$
C. 1 M $LiBr(aq)$
D. 1 M $KF(aq)$

Question 17.

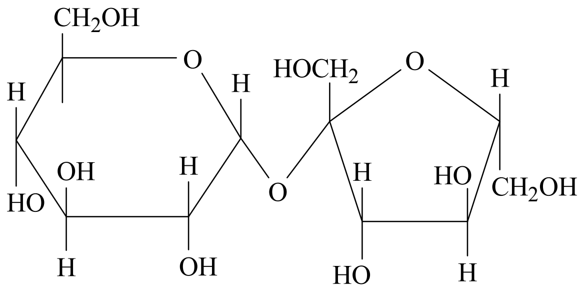
The amino acids lysine and glutamic acid are represented by the semi-structural formulae shown below

$NH_2CHCOOH$	$NH_2CHCOOH$
|	|
$(CH_2)_4$	$(CH_2)_2$
|	|
NH_2	$COOH$
Lysine	

In an aqueous solution of pH 12,

A. lysine molecules will be converted to ions each carrying a +1 charge
B. lysine molecules will be converted to ions each carrying a -1 charge
C. glutamic acid molecules will be converted to ions each carrying a +1 charge
D. glutamic acid molecules will be converted to ions each carrying a -1 charge

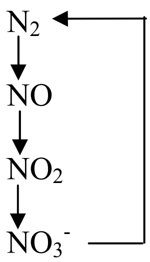
Question 18.
The structure of a common carbohydrate is shown below



The digestion of this carbohydrate produces
A. a pair of structural isomers
B. glucose and maltose
C. carbon dioxide and water
D. glycogen

Question 19.
Olive oil usually contains two polyunsaturated fatty acids; both of which have the same number of C atoms in their molecules.
Linoleic acid which is approximately 9% by mass of the oil and has the molecular formula $C_{18}H_{32}O_2$
Linolenic acid which is approximately 1% by mass of the oil and has a relative molecular mass of 278.
Linolenic acid molecules have
A. one C=C double bond
B. two C=C double bonds
C. three C=C double bonds
D. four C=C double bonds

Question 20.
Part of the nitrogen cycle may be represented as shown below



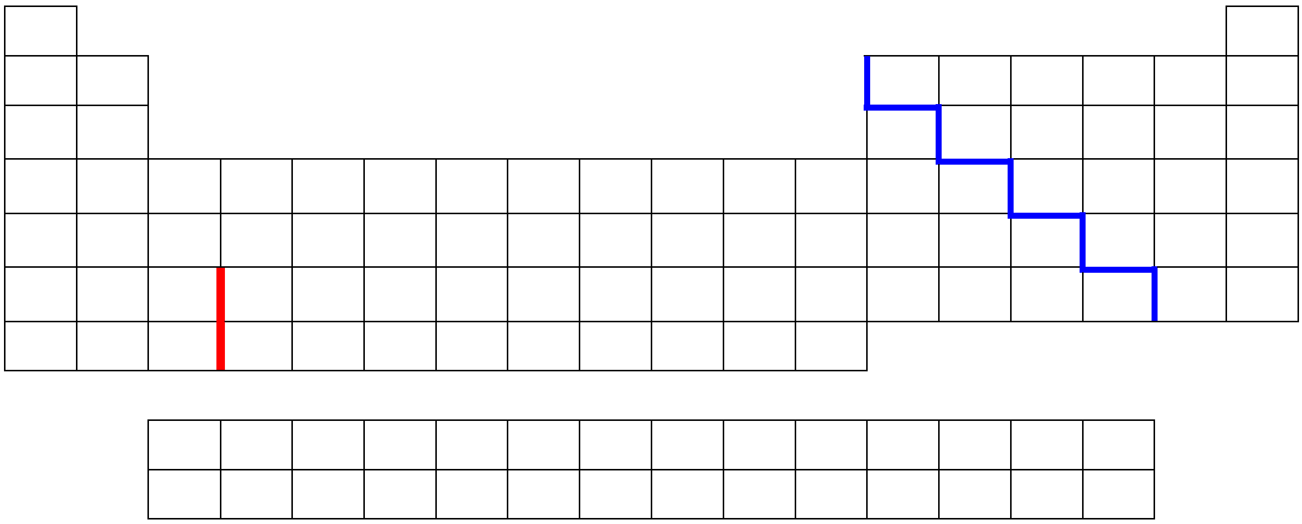
Which one of the following could **not** be involved in this part of the nitrogen cycle?
A. nitrogen fixing bacteria
B. high temperature combustion
C. lightning
D. denitrifying bacteria.

Section B

Section B consists of 5 short answer questions.
You should answer all of these questions.
This section is worth approximately 75% per cent of the total marks available.
You should spend approximately 68 minutes on this section of the examination.
The marks allotted are shown at the end of each part of each question.
Questions should be answered in the spaces provided.

Question 1.

For each part of this question, write, in its correct location on the blank periodic table below, the chemical symbol of the element which best matches the description given.



a) The most abundant element in the universe

b) The anode product of the electrolysis of molten potassium bromide

c) The cathode in a galvanic cell made from a Ni^{2+}(aq)/Ni(s) half-cell and a Pb^{2+}(aq)/Pb(s) half-cell.

d) The nucleus produced when a ^{192}Os nucleus emits a β-particle, i.e. $^{0}_{-1}e$

e) The gaseous product of photosynthesis.

f) The most electronegative element.

g) The element with atoms that have seven fully occupied subshells in the ground state.

h) The anodes used in the industrial production of aluminium by electrolysis.

i) In the third period and forms an oxide which, whilst insoluble in water, reacts with aqueous solutions of both hydrochloric acid and sodium hydroxide.

j) The first transuranium element

10 marks

Question 2.
The heat of combustion of 1-propanol, C_3H_8O was determined by bomb calorimetry. The procedure followed is described in the flowchart below.

0.580 g of 1-propanol was placed in the reaction bomb in the bomb calorimeter

↓

Excess oxygen is pumped into the bomb calorimeter → Temperature of the water in the calorimeter is 21.5 °C.

↓

The mixture in the calorimeter is sparked and the 1-propanol completely reacted with oxygen → Temperature of the water after the reaction is 32.9 °C.

↓

A current of 3.00 A is passed through the heating coil in the water for 150 sec at a potential difference of 5.00 V → Temperature of the water after calibration is 34.2 °C.

(a) Calculate the calibration factor of the calorimeter in kJ $°C^{-1}$

2 marks

(b) Calculate the energy released, in kJ, by the combustion of the 1-propanol in the calorimeter

2 marks

(c) Calculate the heat of combustion of 1-propanol, in

(i) kJ g^{-1}

(ii) kJ mol^{-1}

1+1 = 2 marks

(d) Write a balanced equation describing the combustion of 1-propanol.

2 marks

(e) Calculate the ΔH for the equation in (d)

2 marks

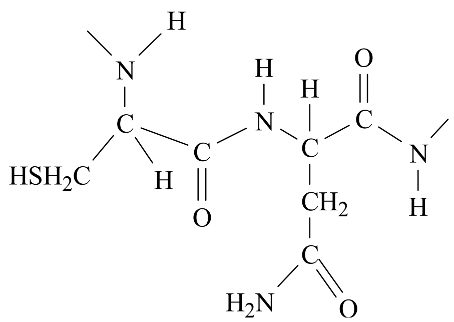
(f) Explain why the heat of combustion of petrol cannot be expressed in kJ mol^{-1}

1 mark

Total 11 marks

Question 3.

The diagram below shows a segment of a large molecule found in biological systems



(a) To what group of biological compounds does this molecule belong?

1 mark

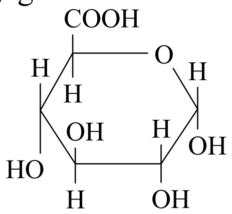
(b) Name the type of reaction involved in the formation of this molecule.

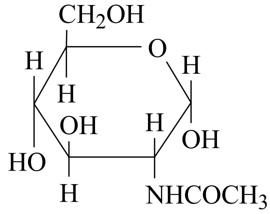
1 mark

(c) Molecules of this type assume particular structures based on bonding between different sections of the same molecule. Explain how hydrogen bonds influence the structure of these molecules.

2 marks

(d) Hyaluronic acid, a lubricant in bone joints, is a polysaccharide formed from the monosaccharides glucuronic acid and acetylglucosamine. Their structures are shown below





glucuronic acid   acetylglucosamine

(i) On each of the structures above circle one functional group on each molecule which could be involved in the reaction to produce hyaluronic acid.

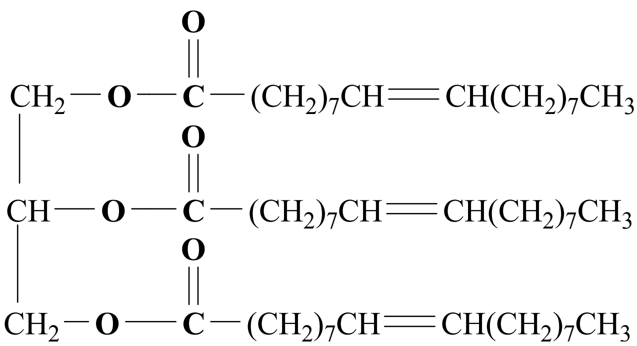
(ii) Write the name of the functional group formed when glucuronic acid and acetylglucosamine react together to produce hyaluronic acid.

(iii) Write the name and chemical formula of the monosaccharide from which the polysaccharides associated with the human diet are made?

(iv) Briefly describe the function of each of the three polysaccharides associated with the human diet.

1+1+1+3 = 6 marks

(e) Write semistructural formulae for the products of digestion of the substance shown below.



2 marks

(f) Write the names and chemical formula of the three compounds considered to be the 'end products of the body's use of food'.

3 marks

Total 15 marks

Question 4.

Hydrogen has recently charged into public awareness because of its potential benefits as an alternative to fossil fuels as an energy source.

(a) Write a balanced equation describing the combustion of hydrogen.

1 mark

(b) What would be the main environmental benefit of replacing fossils fuels with hydrogen as an energy source?

1 mark

(c) Hydrogen can be produced by the electrolysis of a dilute aqueous solution of potassium chloride. Write balanced half-equations for the reactions occurring at the (-) and (+) electrodes during this electrolysis.

(-) electrode

(+) electrode

2 marks

(d) Explain why hydrogen is not initially produced during the electrolysis of a 1M aqueous solution of copper(II) chloride.

2 marks

(e) Solar (photovoltaic) cells are considered to be a more environmentally desirable way of producing the electrical energy needed to produce hydrogen by electrolysis.

(i) Briefly describe the environmental advantage of solar cells and also identify one current problem with this technology.

(ii) What is the main energy transformation occurring in a photovoltaic cell?

2+1 = 3 marks

(f) Explain, using a balanced equation, how hydrogen is the 'source' of solar energy.

2marks

(g) Hydrogen-oxygen fuel cells provide a clean, efficient way to convert chemical energy directly into electrical energy.

(i) Write a balanced half-equation for the anode reaction in a hydrogen-oxygen fuel cell using an alkaline electrolyte.

(ii) State three essential properties of the electrodes in a hydrogen-oxygen fuel cell.

1+2 = 3 marks

Total 14 marks

Question 5.

(a) Ammonium nitrate, NH_4NO_3, a common fertiliser plays a significant role in food production. Why are nitrogenous fertilisers an essential part of the nitrogen cycle?

2 marks

(b) Lecithin, which has molecules with distinct polar and non-polar regions, is present in many foods! How does lecithin improve the quality of these foods?

2 marks

(c) Potassium atoms are larger than sodium atoms but have a lower first ionisation energy. Explain!

2marks

(d) Calcium atoms and manganese atoms both have two electrons in their fourth shells. Why does calcium exhibit only the +2 oxidation state in its compounds whereas manganese can exhibit oxidation states as high as +7?

2 marks

(e) When a freshly cut banana is exposed to air it quickly starts to brown. However if the lemon juice is squirted over the freshly cut banana the onset of browning is significantly delayed. What is the chemical basis of these observations?

2 marks

Total 10 marks

End of Exam

Suggested Answers VCE Chemistry 2007 Trial Exam Unit 4

Section A

Q1. B The formation of **complex-ions** in which the ligand is NH_3 is a characteristic of **transition metal cations**, i.e. Ni^{2+} but not cations of group 1 and 2 cations, i.e. Na^+, Mg^{2+}, Li^+

Q2. C The atomic number of ^4He is 2 and the atomic number of ^1n (a neutron) is 0.
So equation 2. becomes

$$X + X \rightarrow {}^4_2He + 2\,{}^1_0n$$

Since **atomic numbers and mass numbers must equal out on both sides of the equation** the two X nuclei must have a total atomic number of 2 and a total mass number of 6, i.e. X has atomic number 1 and mass number 3 – an isotope of hydrogen.
Equation 1. becomes

$$Y + {}^1_0n \rightarrow {}^4_2He + {}^3_1H$$

So **Y** has **atomic number 3** and **mass number 6**, and is lithium-6; $\mathbf{{}^6_3Li}$

Q3. A Pauli – an orbital may contain 0, 1 or 2 electrons but never more than 2.
Bohr – used emission spectrum of hydrogen as an insight to propose the existence of energy levels for electrons.
Rutherford – used the 'gold foil' experiment as the basis of the nuclear model of the atom.
Dalton – proposed the first atomic theory.

Q4. D When current passes through a sodium lamp, Na atoms are excited and electrons move to higher energy levels. Specific quantities of energy, equal to the difference between starting and finishing energy levels are required for these electron transitions to occur. (These energy quantities appear as black lines on the ROYGBIV background on an absorption spectrum).**When excited atoms return to their ground states**, i.e. electrons move from higher energy levels to lower energy levels, **specific quantities of energy are emitted**, again corresponding to the difference between the initial and final energy levels. These specific quantities of energy (**differences between energy levels**) **correspond to specific wavelengths of light**, each of which is shown by a **coloured line** on the emission spectrum.

Q5. C An element with a high electronegativity has a strong attraction for valence electrons. The most electronegative element is fluorine, which exists as F^- ions, i.e. anions, in many of its compounds.
Electronegativity increases across a period. Oxide properties change from basic to acidic across a period. So an element with high electronegativity would be expected to form an acidic oxide.
First ionisation energy – the energy needed to remove the highest energy (outermost) electron from an atom – **increases with increasing attraction for valence electrons**. So **an element with high electronegativity will have high first ionisation energy**.
Reductants cause reduction and are themselves oxidised. Reductants give up electrons in chemical reactions hence do not have particularly strong attraction for their valence electrons, so will not have a high electronegativity.

Q6. B Mendeleev arranged the elements on his periodic table in order of increasing atomic weight and grouped them on the basis of similar chemical properties. He also left gaps in the table and accurately predicted the properties of then yet to be discovered elements.
However **Mendeleev gave precedence to chemical properties and so placed Iodine (I) after Tellurium (Te) even though the atomic of tellurium was greater.**
Mendeleev decided his atomic weight of Te was incorrect. However, the discovery and eventual understanding of isotopes showed that the higher atomic weight of Te compared to I reflects the relative isotopic composition of the elements.

Q7. D The fusion reaction occurring in the Sun is generally represented by the equation

$4{}^1_1H^+ \rightarrow {}^4_2He^{2+} + 2{}^0_1e^+$ or $4{}^1_1H \rightarrow {}^4_2He + 2{}^0_1e$

This equation shows that the **number of nuclei decreases** as four H-1 nuclei are converted to one He-4 nucleus.
During fusion mass is converted into energy according to Einstein's $E = mc^2$, so the **mass of the star is continuously decreasing**.

Q8. D Reaction at the cathode is $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

$n(e^-) = Q / F$
$= 20000 / 96500$
$= 0.207$ mol

$n(Cu^{2+})$ reacting $= ½ \times n(e^-)$
$= ½ \times 0.207$
$= 0.104$ mol

$n(Cu^{2+})$ initially $= cV = 1.0 \times 1 = 1$ mol
$n(Cu^{2+})$ remaining $= 1 – 0.104$
$= 0.9$ mol
$c(Cu^{2+})$ remaining $= c / V = 0.9 / 1$
$=$ **0.9 M**

Q9. D The species present in the solution are show below as they appear in the electrochemical series

$Cl_2(g) + 2e^- \rightarrow$ **$2Cl^-$**(aq)	1.36 V
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2$**$H_2O$**$(l)$	1.23 V
Cu^{2+} $(aq) + 2e^- \rightarrow Cu(s)$	0.34 V
Fe^{2+} $(aq) + 2e^- \rightarrow Fe(s)$	-0.44 V
Zn^{2+} $(aq) + 2e^- \rightarrow Zn(s)$	-0.76 V
2**H_2O**$(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V

In the electrolysis of a mixture of oxidants and reductants in a dilute solution, the strongest oxidant and strongest reductant react. The strongest oxidant is reduced at the cathode whilst the strongest reductant is oxidised at the anode.
So the **initial reaction**s are
Anode (+) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$
Cathode (-) **$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$**
As the electrolysis continues and all the $Cu^{2+}(aq)$ has reacted, **the next strongest oxidant**, $Fe^{2+}(aq)$, is **reduced** at the cathode according to
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$.
Subsequently, the next strongest oxidant, $Zn^{2+}(aq)$, is reduced according to
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$.
So the **coatings on the graphite cathode**, from the inside out, would be **Cu then Fe then Zn**.

Q10 A The discharging reaction is the reverse of the recharging reaction, i.e.

$Pb(s) + PbO_2(s) + 4H^+(aq) + 2SO_4^{2-}(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

Since discharging is a spontaneous process, oxidation occurs at the (-) electrode and reduction occurs at the (+) electrode.
Pb is oxidised to $PbSO_4$ at the (-) electrode, as the **oxidation number** of lead **increases from 0 to +2** at this electrode.
PbO_2 is reduced to $PbSO_4$ at the (+) electrode, as the **oxidation number** of lead **decreases form +4 to +2** at this electrode.

Q11. C Reference to the electrochemical series enables the determination of the cell voltage under standard conditions (25°C, 1 M, 101.3 kPa).

$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$ 1.09 V

$\mathbf{Ag^+}(aq) + e^- \rightarrow Ag(s)$ 0.80 V

$I_2(s) + 2e^- \rightarrow 2\mathbf{I^-}(aq)$ 0.54 V

A cell potential difference of **0.26 V** could be produced, under ideal conditions, from the combination of the **Ag^+/Ag (0.80 V) and I_2/I^- (0.54 V) half-cells**.

$E_{cell} = 0.80 - 0.54 = 0.26$ V

Since it is a galvanic cell, the oxidant must be higher on the electrochemical series. So the redox reaction is between $Ag^+(aq)$ and $I^-(aq)$ according to the half-equations

$Ag^+(aq) + e^- \rightarrow Ag(s)$ – at the left hand electrode, and

$2I^-(aq) \rightarrow I_2(s) + 2e^-$ – at the **right hand electrode.**

Q12. D For the combustion of **octane**

$$2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g), \Delta H = -10090 \text{ kJ mol}^{-1}$$

A. 2 mol $C_8H_{18} \rightarrow 10090$ kJ

2 x 114 g $C_8H_{18} \rightarrow 10090$ kJ, so 1 g $C_8H_{18} \rightarrow 10090 / 228 =$ **44.3 kJ**

B Produces 16 mol CO_2 for 10090 kJ,

i.e. 16 / 10090 = **0.00159 mol CO_2** for 1 kJ of energy

C Uses 25 mol O_2 for 10090 kJ energy

i.e. 25 / 10090 = **0.0025 mol O_2** for 1 kJ energy

D 2 mol $C_8H_{18} \rightarrow 16$ mol CO_2

2 x 114 g $C_8H_{18} \rightarrow 16$ mol CO_2, so 1 g $C_8H_{18} \rightarrow 16 / 228 =$ **0.070 mol CO_2**

For the combustion of ethanol

$$C_2H_5OH(l) + 9O_2(g) \rightarrow 2CO_2(g) + 6H_2O(g), \Delta H = -1367 \text{ kJ mol}^{-1}$$

A. 1 mol $C_2H_5OH \rightarrow 1367$ kJ

46 g $C_2H_5OH \rightarrow 1367$ kJ, so 1 g $C_8H_{18} \rightarrow 1367 / 46 =$ **29.7 kJ**

B Produces 2 mol CO_2 for 1367 kJ,

i.e. 2 / 1367 = **0.00146 mol CO_2** for 1 kJ of energy

C Uses 9 mol O_2 for 1367 kJ energy

i.e. 9 / 1367 = **0.0067 mol O_2** for 1 kJ energy

D 1 mol $C_2H_5OH \rightarrow 2$ mol CO_2

46 g $C_2H_5OH \rightarrow 2$ mol CO_2, so 1 g $C_2H_5OH \rightarrow 2 / 46 =$ **0.043 mol CO_2**

Compared to the combustion of octane, the combustion of ethanol

- releases **less** energy for each gram combusted (29.7 kJ against 44.3 kJ
- produces **less** CO_2 for each kJ of energy released (0.00146 mol against 0.00159 mol)
- uses **more** O_2 for each kJ of energy produced (0.0067 mol against 0.0025 mol)
- **produces less CO_2 for each gram combusted** (0.043 mol against 0.070 mol)

Q13. B Use the specific heat of water, 4.18 J g^{-1} °C^{-1}, calculate the energy needed to raise the temperature of 150 g of water by one degree.

$\boldsymbol{E}$ = 4.18 J g^{-1} °C^{-1} x $m(H_2O)$ x ΔT

= 4.18 x 150 x 1

= 627 J

The calibration factor is the energy required to raise the temperature of the calorimeter and its contents by one degree. Since 627 J is required just for the 150 mL of water, the calibration factor must be higher because the other components, e.g. the reaction container, stirrer, etc must also have their temperature increased by one degree. Since these have lower heat capacities than water, the calibration factor will be greater, but not significantly greater than 627 J K^{-1}. So **700 J K^{-1}** is the best alternative.

NB Since we are considering a temperature change, J K^{-1} and J °C^{-1} are equivalent.

Q14. A The electrolysis of $NaCl(l)$ to produce $Na(l)$ and $Cl_2(l)$ is carried out industrially in the **Down's Cell.**

Anode (+) – Oxidation: $\mathbf{2Cl^-(l) \rightarrow Cl_2(g) + 2e^-}$

Cathode (-) – Reduction: $\mathbf{Na^+(l) + e^- \rightarrow Na(l)}$

Q15. B The choice between alternatives A, B and C can be made with some reference to the electrochemical series.

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36 V
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	-0.44 V
$\mathbf{Na^+}(aq) + e^- \rightarrow Na(s)$	-0.76 V
$\mathbf{Ca^{2+}}(aq) + 2e^- \rightarrow Ca(s)$	-2.87 V

Alternative A is not correct because, even though sodium is a stronger reductant than iron. Reductants are not reduced; they cause reduction and consequently are oxidized.

Alternative C is not correct because Na^+ is a stronger reductant than Ca^{2+} and so is preferentially reduced. Also the role of $CaCl_2$ in the cell is to lower the melting temperature of NaCl.

Alternative D is not correct because, since Fe is used as the cathode it clearly does not react with the electrolyte, $NaCl(l)$ l$C_aCl_2(l)$.

According to the electrochemical series (even allowing for conditions well beyond the standard 25°C) **Fe is a stronger reductant and would be oxidised in preference to $\mathbf{Cl^-(l)}$**.

Q16. C According to the electrochemical series, O_2, can be produced by the oxidation of $H_2O(l)$ or $OH^-(aq)$. The respective oxidation half-equations are

$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$, or

$4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

If oxygen is not produced during the electrolysis of the 1 M aqueous solution, it will be because of the presence of a reductant stronger than $H_2O(l)$ or, in the case of 1 M NaOH, stronger than $OH^-(aq)$.

Considering the positions of the reductants on the electrochemical series

$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	2.87 V
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36 V
$\mathbf{O_2}(g) + 4H^+(aq) + 4e^- \rightarrow 2\mathbf{H_2O}(l)$	1.23 V
$Br_2(g) + 2e^- \rightarrow 2Br^-(aq)$	1.09 V
$\mathbf{O_2}(g) + 2H_2O(l) + 4e^- \rightarrow 4\mathbf{OH^-}(l)$	0.40 V

In 1 M NaOH, the strongest reductant is $OH^-(aq)$

In 1 M $MgCl_2$ the strongest reductant is $H_2O(l)$

In **1 M LiBr the strongest reductant is $\mathbf{Br^-(aq)}$, so it is oxidized in preference to $\mathbf{H_2O(l)}$ and $\mathbf{Br_2(l)}$ is produced at the anode instead of $\mathbf{O_2(g)}$.**

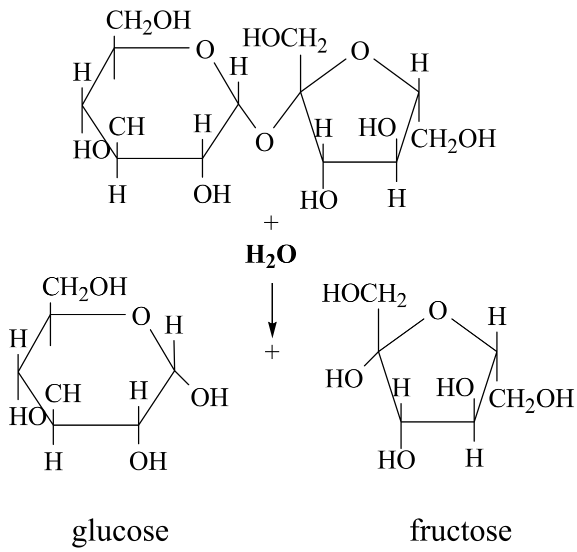
In 1 M KF(aq), the strongest reductant is $H_2O(l)$.

Q17. B In solutions of pH 12, i.e. alkaline solutions, the amino acids will act as 'acids' and donate a proton from their carboxyl (COOH) functional groups. So the structures of the amino acids become

```
NH2CHCOO-            NH2CHCOO-
   |                    |
 (CH2)4               (CH2)2
   |                    |
  NH2                  COO-
```

So the lysine molecules will assume an overall (-1) charge and the glutamic acid molecules will assume an overall (-2) charge.

Q18. A The carbohydrate shown is a disaccharide (sucrose) and digestion involves a reaction with water (hydrolysis reaction) at the ether functional group**.**



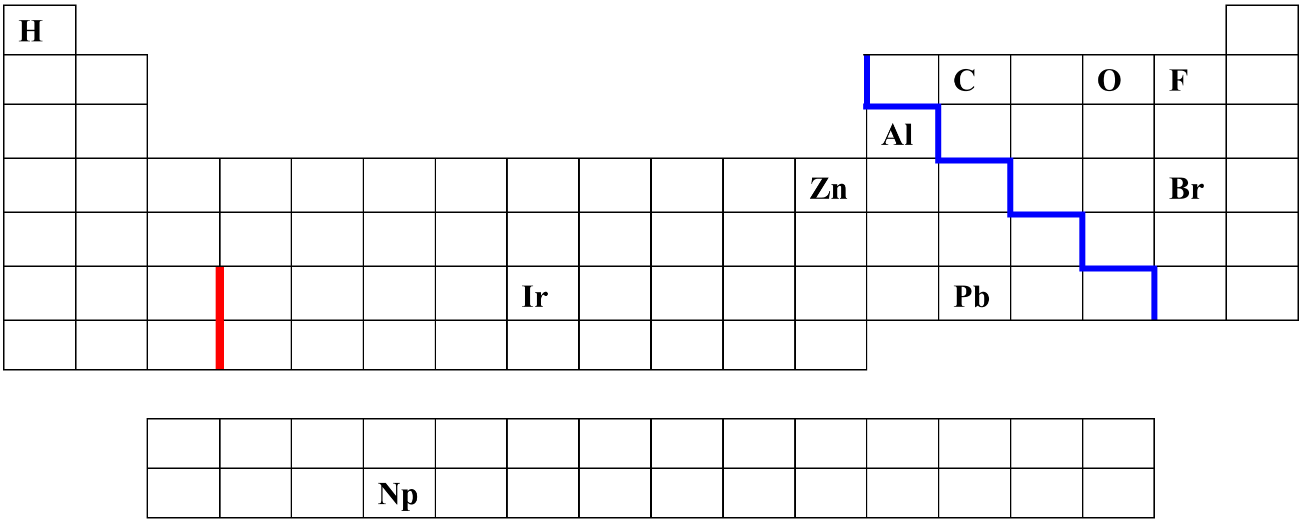
The products of digestion – glucose and fructose – both have the molecular formula, $C_6H_{12}O_6$, and thus are structural isomers.

Q19. C Linoleic and linolenic acids both have 18 carbon atoms in their molecules.
A saturated fatty acid with 18 carbon atoms has the molecular formula $C_{18}H_{36}O_2$ ($C_nH_{2n}O_2$).
Each C=C double bond in a molecule of an unsaturated fatty acid decreases the number of H atoms in the molecule by two compared to the number present in a molecule of a saturated fatty acid with the same number of C atoms.
Linoleic acid molecules – $C_{18}H_{32}O_2$ – each have two C=C double bonds.
$M_r(C_{18}H_{32}O_2) = 18 \times 12 + 32 \times 1 + 2 \times 16$
$= 280.$
Since M_r (linolenic acid) – 278 – is two smaller than M_r (linoleic acid) it must have two fewer H atoms, thus one more C=C double bonds.
So **linolenic acid ($C_{18}H_{30}O_2$) has three C=C double bonds**
Semistructural formulae of the fatty acids are
Linolenic acid $CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$.
Linoleic acid $CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$.

Q20. A Consider the role of each of the alternatives in the nitrogen cycle.
Nitrogen fixing bacteria convert atmospheric nitrogen to NH_4^+. This is **not** shown in the section of the nitrogen cycle given in the question.
High temperature combustion converts N_2 to NO according to $N_2(g) + O_2(g) \rightarrow 2NO(g)$. This reaction can also be initiated by lightning.
Denitrifying bacteria complete the nitrogen cycle by converting NO_3^- to N_2. They can use the oxygen to oxidise their glucose and obtain energy.

Section B

Question 1.



(a) **H** ❶

Hydrogen is the most abundant element in the universe - over 990 out of every 1000 atoms present.

(b) **Br** ❶

Molten potassium bromide contains $K^+(l)$ and $Br^-(l)$ ions. When electrical current flows through molten KBr, the anions, Br^-, move towards their anode where they are oxidised according to

$$2Br^-(l) \rightarrow Br_2(g) + 2e^-$$

(c) **Pb** ❶

According to the relative positions on the electrochemical series

$$\mathbf{Pb^{2+}}(aq) + 2e^- \rightarrow Pb(s) \qquad -0.13\ V$$

$$Ni^{2+}(aq) + 2e^- \rightarrow \mathbf{Ni}(s) \qquad -0.23\ V$$

The strongest oxidant $Pb^{2+}(aq)$ reacts with the strongest reductant Ni(s).

The reduction $Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$ occurs at the cathode which is Pb.

(d) **Ir** ❶

When a nucleus emits a β-particle, its atomic number increases by 1, which means the element changes to the one following it on the Periodic Table, but the mass number stays the same, as shown in the balanced equation

$$^{192}_{76}Os \rightarrow {}^{192}_{77}Ir + {}^{0}_{-1}e$$

(e) **O** ❶

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6\mathbf{O_2}(g)$$

(f) **F** ❶

Electronegativity increase across a period and decreases down a group.

(g) **Zn** ❶

Based on the order of subshell filling and the maximum number of electrons in each subshell, the electron configuration $1s^22s^22p^63s^23p^64s^23d^{10}$, shows that atoms of the element contain 30 electrons. So the element has atomic number 30, i.e. Zn.

(h) **C** ❶

Aluminium is produced by the electrolysis of alumina, Al_2O_3, dissolved in cryolite. The anode reaction $C(s) + O^{2-}(l) \rightarrow CO_2(g) + 4e^-$, gradually consumes the carbon anodes which are periodically replaced.

(i) **Al** ❶

Al_2O_3 is an amphoteric oxide, reacting according to

$$Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$$

$$Al_2O_3(s) + 2OH^-(aq) + 3H_2O(l) \rightarrow 2Al(OH)_4^-(aq)$$

(j) **Np** ❶
The transuranium elements are the ones following uranium on the periodic table. They have been synthesised by artificial transmutation, based on the bombardment of uranium and subsequent elements with neutrons and small nuclei.

Question 2.

0.580 g of 1-propanol was placed in the reaction bomb in the bomb calorimeter

↓

Excess oxygen is pumped into the bomb calorimeter → Temperature of the water in the calorimeter is 21.5 °C.

↓

The mixture in the calorimeter is sparked and the 1-propanol completely reacted with oxygen → Temperature of the water after the reaction is 32.9 °C.

↓

A current of 3.00 A is passed through the heating coil in the water for 150 sec at a potential difference of 5.00 V → Temperature of the water after calibration is 34.2 °C.

(a) Energy added during calibration = VIt
= 5.00 x 3.00 x 150
= 2.25×10^3 J
= 2.25 kJ ❶

Temperature change during calibration (ΔT_c) = 34.2 – 32.9
= 1.3 °C

Calibration Factor = $E / \Delta T_c$
= 2.25 kJ / 1.3 °C
= **1.73 kJ °C^{-1}** ❶

(b) Temperature change during reaction (ΔT_r) = 32.9 – 21.5
= 11.4 °C ❶

Energy released = Calibration Factor x ΔT_r
= 1.73 kJ °C^{-1} x 11.4 °C
= **19.7 kJ** ❶

(c) (i) Heat of combustion = energy released / $m(C_3H_8O)$
= 19.7 kJ / 0.580 g
= **34.0 kJ g^{-1}** ❶

(ii) $n(C_3H_gO) = m / M$ = 0.580 / 60.0
= 0.00967 mol

Heat of combustion = energy released / $n(C_3H_8O)$
= 19.7 kJ / 0.00967 mol
= **2.04×10^3 kJ mol^{-1}** ❶

(d) $2C_3H_8O(l \text{ or } g) + 9O_2(g) \rightarrow 6CO_2(g) + 8H_2O(g \text{ or } l)$ ❶ for balanced equation; ❶ for correct states

(e) The ΔH value must reflect the number of mole of 1-propanol as shown in the equation. Also because the reaction is exothermic it must have a negative sign.

ΔH = - 2 x 2.04×10^3 kJ mol^{-1}
= **-4.08×10^3 kJ mol^{-1}** ❶❶

(f) Because **petrol is a mixture** (of octane and other alkanes) it **does not have a specific chemical formula nor molar mass**. Hence its heat of combustion is expressed in kJ g^{-1} or kJ L^{-1}. ❶

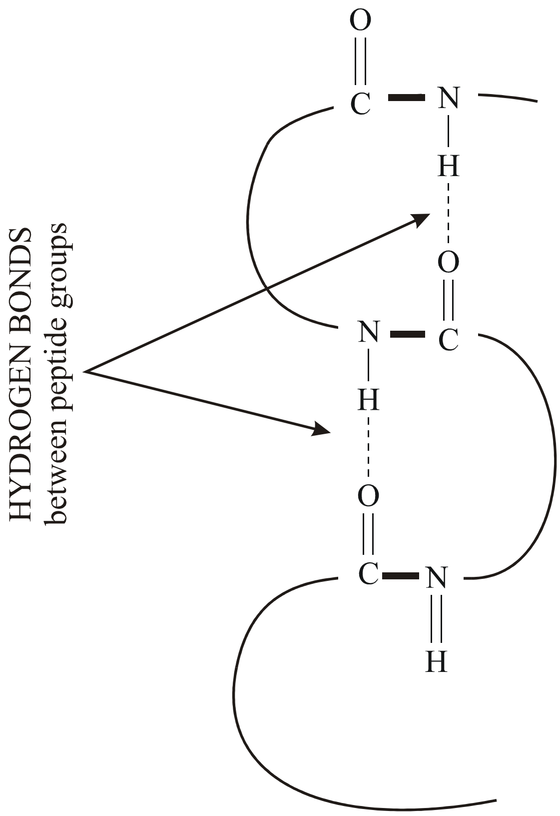
Question 3.

(a) **Proteins** ❶ - identified by the presence of the peptide CONH group

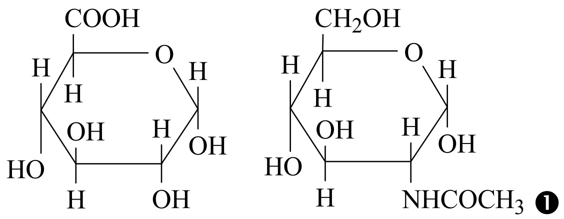
(b) **Condensation** (polymerisation) reaction ❶ - reaction between a carboxyl –COOH group and an amino $–NH_2$ group on adjacent amino acids.

(c) Proteins have a 'secondary structure' in which the molecules assume a helical shape. **The 'secondary' structure is held together by hydrogen bonds between peptide groups on the same chain.** ❶

The **hydrogen bonds form between the O atom on one peptide group and the H atom on another peptide group**, as shown in the diagram on the right. ❶



(d) (i) Circle one hydroxy group on each structure.



Hydroxy groups on adjacent molecules react with each other.

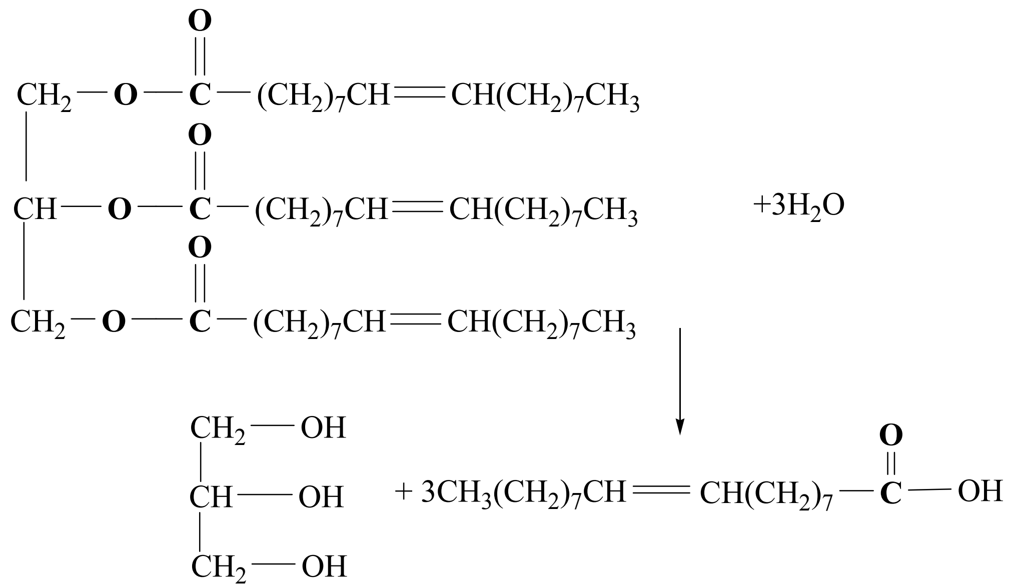
(ii) The hydroxy groups react to produce the **ether** ❶ (C)**-O-**(C) functional group

(iii) **Glucose, $C_6H_{12}O_6$** ❶

(iv) The three polysaccharides associated with the human diet are starch, cellulose and glycogen.
During digestion **starch is broken down into glucose** in an hydrolysis reaction. ❶
Glucose is stored in the body in the form of **glycogen**. ❶
Glycogen is produced from condensation polymerisation of glucose.
Cellulose is not digested (we do not have the appropriate enzyme) but it plays a significant role in the diet as **dietary fibre**. ❶

(e) The structure shown is that of an unsaturated fat. During digestion water reacts at the ester groups, and the fat is hydrolysed to form glycerol and the fatty acid, which have the semi-structural formulae

$CH_2OHCHOHCH_2OH$ ❶ and **$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$** ❶



(f) **Carbon dioxide, CO_2** ❶ and **water, H_2O** ❶ are both produced through the oxidation of carbohydrates, fats and excess protein.
Urea, $(NH_2)_2CO$ ❶ is produced so that the body can eliminate nitrogen from excess protein.

Question 4.

(a) **$2H_2(g) + O_2(g) \rightarrow 2H_2O(g\ or\ l)$** ❶

(b) Because water is the **only product** of the combustion of **hydrogen**, there is **no CO_2 produced**. Since CO_2 production is a key factor in **global warming**, its lack of production is a significant **environmental benefit**. ❶

(c) During electrolysis, electrons are forced to travel from the positive electrode to the negative electrode. Since electrons always move from the anode (site of oxidation) to the cathode (site of reduction), the (-) electrode is the cathode and the (+) electrode is the anode.
In a dilute aqueous solution of potassium chloride there are two oxidants – $Na^+(aq)$ and $H_2O(l)$, and two reductants – $Cl^-(aq)$ and $H_2O(l)$.

$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	1.36 V
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2\mathbf{H_2O}(l)$	1.23 V
$2\mathbf{H_2O}(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V
$K^+(aq) + e^- \rightarrow K(s)$	-2.93 V

Reaction is between the strongest oxidant and the strongest reductant, so the half-equations are
(-) electrode **$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$** ❶
(+) electrode **$2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$** ❶

(d) On the basis of the electrochemical series

$\mathbf{Cu}^{2+}(aq) + 2e^- \rightarrow 2\mathbf{Cu}(s)$	0.34V
$2\mathbf{H_2O}(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	-0.83 V

$Cu^{2+}(aq)$ is a stronger oxidant than H_2O ❶, and so is **preferentially reduced** according to $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$. ❶

(e) (i) The environmental advantage of solar cells is **lack of pollution**. ❶
A significant problem with solar cells is their relatively **low efficiency**. ❶
You could also comment on the large solar collection area required, use being limited to regions with significant sunshine, cost.

(ii) **Light energy to electrical energy.** ❶

(f) The Sun's energy is released via **nuclear fusion** reactions. **Nuclear energy is converted into other forms of energy by the fusion of hydrogen nuclei to form helium nuclei** ❶ , generally represented by the equation

$$\mathbf{4\,^1_1H \rightarrow \,^4_2He^{2+} + 2\,^0_1e^+} \text{ or } \mathbf{4\,^1_1H \rightarrow \,^4_2He + 2\,^0_1e^+}$$ ❶

(g) (i) The fuel, H_2, is oxidised at the anode, so use the electrochemical series to find H_2 in a half equation with an alkaline electrolyte.

$2H_2O(l) + 2e^- \rightarrow \mathbf{H_2}(g) + 2\mathbf{OH^-}(aq)$ -0.83 V

The half-equation for the anode reaction is

$\mathbf{H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-}$ ❶

(ii) The electrodes in a hydrogen-oxygen fuel cell must
- **conduct electricity**
- **not react** with the fuel, the oxidant, or the electrolyte
- must be **porous** to allow contact between the fuel and the electrolyte and the oxidant and the electrolyte. ❶❶ *for all three* / ❶ *for two*

Question 5.

(a) **Most plants require fixed nitrogen** to be present in the soil in forms that can be taken in through the roots, such as NH_4^+ and NO_3^- ions, and used t**o produce amino acids and proteins**. ❶ However, such is the demand for food production that **nitrogen fixing by bacteria in the soil does not supply enough nitrogen.**❶ This natural fixing is supplemented by the use of nitrogenous fertilisers such as NH_4NO_3

(b) The polar and non-polar regions on lecithin molecules enables it to acts as an **emulsifier**. ❶ This ensures that all components of the food – polar and non-polar – are smoothly blended as the **lecithin molecules act as chemical bridges between the polar and non-polar food components ❶.** The polar end of the lecithin molecules are attracted to the polar food components whilst the non-polar ends of the lecithin molecules are attracted to the non-polar food components.

(c) The ground state electronic configurations of potassium and sodium are

$_{19}K$ – $1s^22s^22p^63s^23p^64s^1$ and $_{11}Na$ - $1s^22s^22p^63s^1$

K atoms are larger than Na atoms because they have four occupied electron shells compared to three for sodium. ❶

Na and K atoms both have the same **core charge** (+1) – attraction for outer shell electrons – however because this is acting over a larger distance **in K atoms** it is **less effective** and so **less energy is required to remove the electron in the highest energy level**. Therefore K atoms have a lower first ionisation energy than Na atoms. ❶

(d) The electronic configurations of Ca and Mn are

$_{20}Ca$ - $1s^22s^22p^63s^23p^64s^2$ and

$_{25}Mn$ - $1s^22s^22p^63s^23p^64s^23d^5$

Calcium exhibits an **oxidation state** of **+2** because it can **donate both of its 4s electrons** when bonding. ❶

The **similarity in energy of the 4s and 3d electrons means than Mn atoms can use electrons from both subshells** when bonding, and hence exhibit oxidation numbers as high as +7. ❶

(e) **The browning of freshly cut banana is due to** a reaction with atmospheric oxygen. Lemon juice contains **ascorbic acid** which **acts as an antioxidant**. ❶ It **reacts preferentially with atmospheric oxygen** ❶ and so slows down the browning of the banana.